UCRL-JC-125611 Abs

Thermal-mechanical-hydrological-chemical responses in the Single Heater Test at the ESF

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Yucca Mountain Site Characterization Project (YMP) is studying the feasibility that Yucca Mountain can be used as a potential repository for high-level nuclear wastes. The study includes prediction of the quantity and quality of water in the near-field of a repository. The quality and quantity of water in the near-field of a repository will affect the release rate of radioactive nuclides from waste packages, and the transport of the nuclides through the rock mass adjacent to the waste package. The radioactive decay heat from the high-level nuclear waste may generate the coupled thermal-mechanical-hydrological-chemical (TMHC) processes in the originally partially saturated Topopah Spring tuff, which is the potential host rock in Yucca Mountain. Modeling the coupled TMHC processes is necessary in order to predict the quantity and quality of water in the near-field environment of a repository. In situ thermal tests are required to build up the confidence level of the coupled TMHC models.

The Single Heater Test (SHT) is one of the in situ thermal tests being conducted in the Exploratory Studies Facility (ESF) in Yucca Mountain to enhance the understanding of the coupled processes. The primary objective of the SHT is to investigate the thermal-mechanical responses of the Topopah Spring tuff in Yucca Mountain. It is also used as a shake-down for in situ testing of the coupled TMHC processes. This paper describes the SHT, and reports the progress of the thermal-mechanical-hydrological-chemical part of the SHT.

The SHT is located off the Observation Drift at about 40 m from the Main Tunnel of the ESF, at about 2.8 km from the portal of the Tunnel. As shown in Figure 1, the heated block of the SHT is bounded by the Observation Drift, Thermal-mechanical Alcove, and Thermal-mechanical Alcove Extension. One single element electrical heater was placed in a heater hole which was drilled horizontally into the heated block, at about the middle of the Thermal-mechanical Alcove at about 1.5 m from the floor. The total power output of the heater is about 4 kW. The heater element is about 5 m in length. The heated part of the heater hole starts at about 2 m from its collar. Figure 1 also shows the borehole layout in the SHT. Borehole #1 is the heater hole; #2 to 4 , 8 to 14, 19, and 28 to 41 are for thermal-mechanical studies. In addition, the following holes are for testing the coupled TMHC processes: #15, 17, 22, and 23 are for resistance temperature devices (RTD) to measure temperature and neutron logging to map moisture distribution; #16 and 18 are for measurement of relative humidity, gas pressure, and testing waste package material and introduced materials; #20 and 21 are for measuring concentration of chemical species (including pH, chloride, sulfide, dissolved oxygen, potassium, calcium, sodium, oxidation/reduction potential, and corrosion potential) and fluid extraction; #24 to 27 are for using electrical resistivity tomography (ERT) to image 2-dimensional moisture distribution; and #6 and 7 are for optical extensometers using a laser to measure displacement along the boreholes.

The heater was energized on August 26, 1996 to a full power of about 4 kW. By October 1, 1996, the boiling point isotherms were between 0.34 and 0.67 m radially from the middle of the heater. There has been no significant movement of moisture recorded by neutron logging and

ERT. ERT registered a lower resistivity region around the heater. But that is probably due to the increase in temperature. No significant changes in relative humidity and gas pressure have been recorded yet. Nor have the chemical sensors registered significant changes. Data will be continuously analyzed whenever they are available.

This work is performed under the auspices of the U.S. Department of Energy by Lawrence Livermore National Laboratory under contract W-7405-ENG-48. This work is supported by Yucca Mountain Site Characterization Project, LLNL.

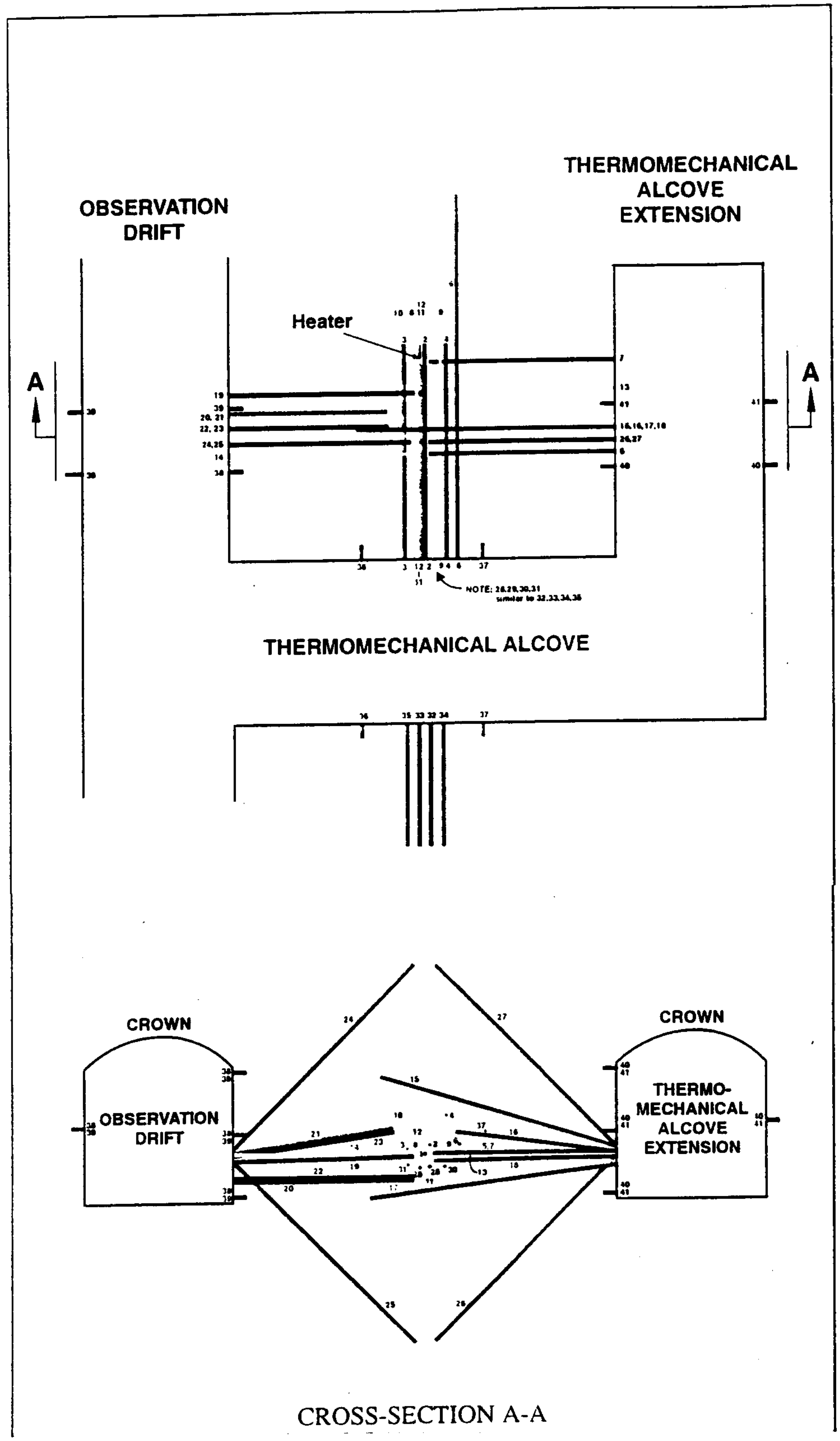

Figure 1. Layout of the Single Heater Test